Geoscience Canada

Recent Sediments: The Front Line of Environmental Protection

W. S. Fyfe

Volume 9, Number 1, March 1982

URI: https://id.erudit.org/iderudit/geocan9_1aqg10

See table of contents

Publisher(s)

The Geological Association of Canada

ISSN

0315-0941 (print)
1911-4850 (digital)

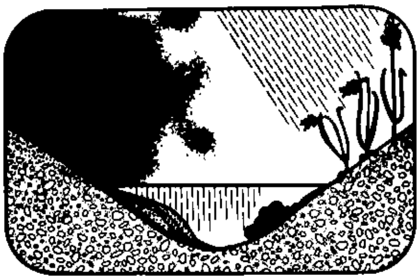
Explore this journal

Cite this article

Fyfe, W. S. (1982). Recent Sediments: The Front Line of Environmental Protection. *Geoscience Canada*, *9*(1), 71–73.

Article abstract

Man has become the greatest agentmodifying surface environmentalsystems. Our knowledge of the balancebetween these systems is inadequate andat present we cannot predict theconsequences of major perturbations.Perhaps the greatest problem facing ourscience is the understanding of climatebut if such knowledge is to be obtained,the record must be extracted from rocksnear the surface of the earth.



Recent Sediments: The Front Line of Environmental Protection

W.S. Fyfe
Department of Geology
University of Western Ontario
London, Ontario N6A 5B7

Abstract

Man has become the greatest agent modifying surface environmental systems. Our knowledge of the balance between these systems is inadequate and at present we cannot predict the consequences of major perturbations. Perhaps the greatest problem facing our science is the understanding of climate but if such knowledge is to be obtained, the record must be extracted from rocks near the surface of the earth.

Introduction

It was not long ago that the Earth and other members of the solar system all seemed large, that resources seemed infinite, that the Earth was empty. The age of science and technology has changed that situation over a period of little more than two centuries and today the rate of change still appears to accelerate. The scientific advances in fields related to energy-health-food, etc., have allowed phenomenal growth to population from about 500 million in 1600 to a billion in 1800, 1.7 billion in 1900 to the present 4.5 billion (Meadows *et al.*, 1972). It is projected that by the year 2000 the human population will increase by 50 per cent and will exceed 6 billion (Barney, 1980). There is little chance that present projections of trends will be much in error for the constraints imposed by social and political dogma show few signs of change.

What few educated people appreciate is that because of the increase in the population of this strange intelligent and inventive species, man has now become the greatest mover of materials on the surface of our planet; man is now the dominant agent of environmental change.

Modern civilized man of North America uses about 20 tons (2×10^7g) of geological materials annually for his needs (Barney, 1980). For a billion such people this quantity, 2×10^{16}g, can be compared with the average rates of andesitic volcanism (3×10^{15}g a^{-1}), ocean ridge crust formation (3×10^{16}g a^{-1}) and total erosion (10^{17}g a^{-1}). Coal alone is mined at a rate of 3×10^{15}g a^{-1}. And if we add to such things the soil moved by agriculture then there is little doubt that we have become the dominant agents for change. Modern studies of element transport to the oceans nicely illustrate this situation as shown in Table 1 from Barney (1980).

What is quite certain at the present time is that we do not appreciate the long term consequences of our present activity. In most situations we do not monitor changes in any adequate way let alone appreciate the sparse data being accumulated.

The record of what we are doing must be found in the most recent sediments of the planet. The record of natural fluctuations is recorded in earth materials of all ages but the record will be most susceptible to exact interpretation for rocks formed over the past few million years. If we are to understand the stresses on the environment being imposed by man and if we are to minimize the strains, there must be a greatly accelerated effort in the study of modern processes. At the present time the impact of the small amount of work in these fields is further reduced by the fragmentation of effort. Thus one may find interesting studies being carried out in departments of chemistry, geology, geography, engineering, anthropology, physics or biology, with little interaction between the groups and in most cases, only one or two workers will be involved in such studies.

Table I. *Natural and man-made fluxes of metals into the oceans (x10³ tons per year). Data from Barney (1980).*

	Natural	By Man
Iron	25,000	319,000
Manganese	440	1,600
Copper	375	4,460
Zinc	370	3,930
Nickel	300	358
Lead	180	2,330
Molybdenum	13	57
Silver	5	7
Mercury	3	7
Tin	1.5	166
Antimony	1.3	40

The Great Problems

It is difficult to place the great natural needs of the population (10 billion) of the next century in any order of priority, all are so closely linked. But the list will include needs for energy, water, clean air, food, shelter. Given that at present about a billion people suffer from severe malnutrition and that 35,000 young children die daily of malnutrition and waterborne disease, it is clear that for all our advances we are not coping with present demand. The 50 per cent increase in population projected for the year 2000 will have to find support from only a small increase (4%) in arable land (Barney, 1980). As stated in Dolman (1977) "no longer can we afford to live in a world where a few prosper and most are near starvation."

What is urgently needed, and is clearly not available at present, is the data necessary for rational decision making in critical areas such as energy production, land use, resource development. Should we burn more coal or use nuclear energy? Should we farm the Amazon basin? Is biomass energy a viable global alternative? Should we chlorinate increasing quantities of water?

Climate

There is possibly no more urgent scientific problem than that of understanding climate for such understanding is a prerequisite of understanding food production and water supply. Almost every issue of journals such as *Science* or *Nature* contains some contribution on this topic. Much of the present debate centres on the impact of increasing atmospheric carbon dioxide on the atmospheric energy balance. The present state is one of confusion.

Our atmosphere is a complex photochemical system with scores of interactive photochemical systems (McEwan and Phillips, 1975). The present situation is nicely summarized by Wigley *et al.* (1981) who discuss the evidence for a global warming trend. But the climate record is short and finding trends with the high natural background variation is difficult. There are great future possibilities that ocean temperatures can be monitored on a global basis using the Seasat satellite system. At present the sensitivity is about 1° C (Hofer *et al.*, 1981) but this will be improved.

There is no doubt that at the present time the carbon dioxide content of the atmosphere is increasing and there is little doubt that this is due to the increased combustion of carbonaceous materials. This species plays a major role

0315-0941-82-01/071-073 $01.00/0

Figure 1 *Modern agriculture in Washington's Palouse basin. Soil losses in the range 20-200 tons per acre per year. Will the rates increase? Photograph courtesy of James Risser, Bureau Chief in Washington, D.C. of the Des Moines Register and the Smithsonian Magazine.*

in the thermal balance of the environment and as stated by Woodwell (1978) "carbon dioxide, until now an apparently innocuous trace gas in the atmosphere, may be moving rapidly toward a central role as a major threat to the present world order."

But the carbon dioxide content of the atmosphere is only one of several major factors which may influence our climate.

Potter *et al.* (1981) have discussed the influence of man made changes in albedo and conclude that the influence is undetectable. Kukla *et al.* (1981) suggest that orbital variations are the dominant cause of glacial cycles. They conclude that "detailed climate reconstructions or predictions will have to consider interactions of orbital perturbations with changing solar activity and with natural and manmade variables of terrestrial origin." Similar conclusions are reached by Sergin (1980) who notes that "weak temperature fluctuations have been followed by large-scale oscillations."

Modern writing demonstrates the sensitivity of the atmosphere system. Thus ozone is linked to carbon dioxide. Nitrogen fertilizer pollution can perturb both ozone levels and climate by contributing to warming. But the politician must be confused for Idso (1980) concludes that the influence of carbon dioxide build up is overestimated and will be lost in climatic noise. He considers that we should not be too quick to limit our options on energy.

But surely what is needed is a better and more extended record and this record must be found in earth materials. Important studies are in progress. Thus Cronin *et al.* (1981) report on the record from the U.S. Atlantic coastal plain sediments using isotopic, paleontologic and lithologic criteria.

Data from ice cores can reveal information on atmosphere composition and dust concentration. Thus Delmas *et al.* (1980) report that during the last ice age the carbon dioxide content was half the present value. Thompson and Mosley-Thompson (1981) present evidence showing a correlation between global temperatures and microparticle concentration in ice cores. But to improve the quality of all such information there is need of better methods of dating which may well be possible with the new accelator-mass spectrometer combinations (Dansgaard, 1981). In this connection we are fortunate to have the group at Toronto under A.E. Litherland at work on such a machine for Canada (see Purser *et al.*, 1979). Exciting new areas of study are evolving. Thus Woodruff *et al.* (1981) show the detail of the record that can be obtained from deep ocean sediments. New proposals to drill sediments in African lakes may reveal continuous climatic records for 5 to 10 million years (Lewin, 1981).

What is certain is that we have the tools to monitor and describe climate history. The present effort is too small but the consequences of neglect of this field may be catastrophic for the human race.

Conclusion

In this short note I have focussed attention on understanding climate. Perhaps this is the outstanding problem for a crowded planet. But study of recent processes involves many critical areas.

The ultimate success of agriculture depends on the balance between soil chemistry, climate and water. Soil conservation is little understood by many who use this resource. As stated in a recent article (Waldrop, 1981) "Iowa had an average of 8 inches of topsoil when it was settled; today, 100 years later, it has 4. Erosion is causing a steady drop in the productivity of that land equivalent to the loss of 1.25 million acres per year. The difference must be made up with more fertilizers, more pesticides, more petrochemicals and more energy. We're taking out 1 inch of topsoil every 8 to 10 years on the average. The rate at which topsoil is being created from bedrock is about 1 inch per century." Soil forming and destruction processes must be monitored. The examples of such comments could be multiplied with ease.

It appears that in agri-science we are slow to appreciate the laws of conservation of mass. If crops are removed there must be a balanced replacement mechanism for sustained production. If rivers are used for agriculture and are dispersed by evaporation and plant transpiration, salt must build up (Pillsbury, 1981). And what is the long term influence on the ground water reserve?

Perhaps the major conclusion from these notes is that to protect our environment and our most basic resources, we must have a detailed mass balance of all parts of the surface atmosphere-hydrosphere-rock system. Only with such knowledge (be it for CO_2, O_3, acid rain, etc.) can we predict which man-made perturbations are tolerable or intolerable. And studies of the processes of the past few millions of years must provide the basic data.

References

Barney, G.O., 1980, The global 2000 report to the president: United States Government Printing Office, Washington.

Cronin, T.M., B.J. Szabo, T.A. Ager, J.E. Hazel, and J.P. Owens, 1981, Quaternary climates at sea levels of the U.S. Atlantic coastal plain: Science, v. 211, p. 233-240.

Dansgaard, W., 1981, Ice core studies: dating the past to find the future: Nature, v. 290, p. 360-361.

Delmas, R.J., J. Ascencio, and M. Legrand, 1980, Polar ice evidence that atmospheric CO_2 20,000 yr B.P. was 50% of present: Nature, v. 284, p. 155-157.

Dolman, A.J., ed., 1977, Reshaping the International Order: New American Library of Canada Ltd.

Hofer, R., E.G. Njoku, and J.W. Waters, 1981, Microwave radiometric measurements of sea surface temperature from the Seasat satellite: first results: Science, v. 212, p. 1385-1387.

Idso, S.B., 1980, The climatological significance of doubling of earth's atmosphere carbon dioxide concentration: Science, v. 207, p. 1462-1463.

Kukla, G., A. Berger, R. Lotti, and J. Brown, 1981, Orbital signature of interglacials: Nature, v. 290, p. 295-300.

Lewin, G., 1981, Lake bottoms linked with human origins: Science, v. 211, p. 564-566.

McEwan, M.J. and L.F. Phillips, 1975, Chemistry of the Atmosphere: Edward Arnold.

Meadows, D.H., D.L. Meadows, J. Randers, and W.W. Behrens, 1972, The Limits to Growth: New American Library, New York.

Pillsbury, A.F., 1981, The salinity of rivers: Scientific American, v. 245, July 1981, p. 54-65.

Potter, G.L., H.W. Ellsaesser, M.C. MacCracken, and J.S. Ellis, 1981, Albedo change by man: test of climatic effects: Nature, v. 291, p. 47-49.

Purser, K.H., A.E. Litherland, and J.C. Rucklidge, 1979, Secondary ion mass spectrometry at close to single-atom concentration using DC accelerators: Surface and Interface Analysis, v. 1, p. 12-20, 1979.

Sergin, V.Y., 1980, Origin and mechanism of large-scale climatic oscillations: Science, v. 209, p. 1477-1482.

Thompson, L.G. and E. Mosley-Thompson, 1981, Microparticle concentration variations linked with climatic change: evidence from polar ice cores: Science, v. 212, p. 802-815.

Waldrop, M.M., 1981, Deep changes taking root in U.S. agriculture: Chem. Eng. News, June 1, 1981, p. 23-28.

Wigley, T.M.L., P.P. Jones and P.M. Kelly, 1981, Global warming?: Nature, v. 291, p. 285.

Woodruff, F., S.M. Sauin, and R.G. Douglas, 1981, Miocene stable isotope record: a detailed deep Pacific ocean study and its paleoclimatic implications: Science, v. 212, p. 665-668.

Woodwell, G.M., 1978, The carbon dioxide question: Sci. American, v. 238, p. 34-44.

MS received November 2, 1981